

Breast Diffusion-weighted Imaging at 3 and 7 Tesla: Comparison Study

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PURPOSE: Diffusion weighted imaging is a potential method for the detection and characterization of breast cancer [1]. By measuring apparent diffusion coefficient (ADC) values, it is possible to probe the local cellular microstructure in breast tissue. This may be used to distinguish between malignant and benign lesions and to recognize early response in cancer therapy monitoring. High field MR systems offer a potential gain in sensitivity that can be translated to higher spatial resolution. This could improve lesion detection and differentiation. The purpose of this study was to compare bilateral breast-DWI with sub-mm-resolution (0.9mm^2) at 7T with 3T (1.4mm^2) in the same patients.

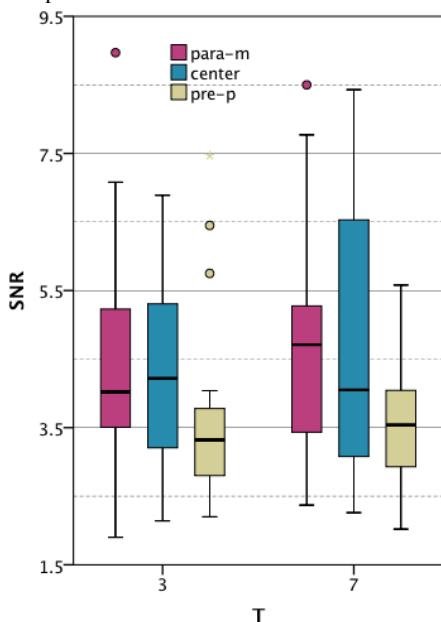


Figure 3: Boxplot of SNR from different breast regions: pink for para-mammilar, blue – central and yellow for pre-pectoral region – at 3T and 7T, n=15.

without enhancement - in the contralateral breast - in three different parts of the breast: para-mammary, central and pre-pectoral, using OsiriX® software. SNR was defined as the ratio between mean signal amplitude inside the ROI (S_{ROI}) and standard deviation of the background noise (σ_{BG}) ($SNR = S_{ROI}/\sigma_{BG}$). The statistical analysis was performed in IBM SPSS Statistics (Armonk, NY). For the analysis, Student's *t*-test was used for healthy tissue data, because of possible difference in partial volume effects in ROIs in lower density breast cases. A paired test was used for benign and malignant lesions data.

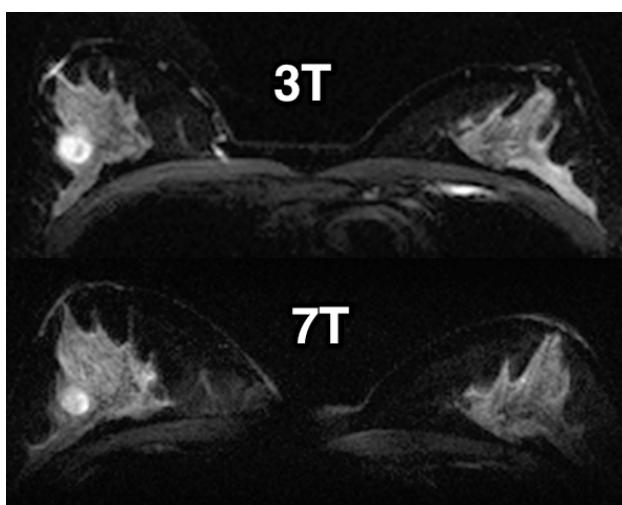


Figure 4: Examples of DWI MRI at $b=0\text{s/mm}^2$ at 3T ($1.4 \times 1.4\text{mm}^2$) and 7T ($0.9 \times 0.9\text{mm}^2$).

METHODS: All experiments were performed at 3T and 7T MRI systems (3T Trio, 7T Magnetom, Siemens Healthcare, Erlangen, Germany) using dedicated bilateral breast coils with four 1H-channels (3T: In vivo, Orlando, FL, USA; 7T: 1H/31P-coil, H. Stark, Erlangen, Germany). This study was approved by the local ethics committee. 15 patients (55+-17yo) were measured at both field strengths within one week. In pre-menopausal women, MRI was performed between day 7 and 14 of the menstrual cycle. Bilateral 3 direction trace DWI was performed in 2:56min (3T) and 3:48min (7T) using combined readout-segmented echo planar imaging (rs-EPI) with fat-suppression and with b -values of 0 and 850 sec/mm 2 . The in-plane resolution was 1.4x1.4mm 2 at 3T and 0.9x0.9mm 2 at 7T with the same slice thickness (5mm). To allow a better resolution at 7T without causing additional blurring or distortions, we used 9 readout segments at 7T compared to 5 at 3T. To compensate for the expected increase in off-resonance effects at 7T, we additionally used

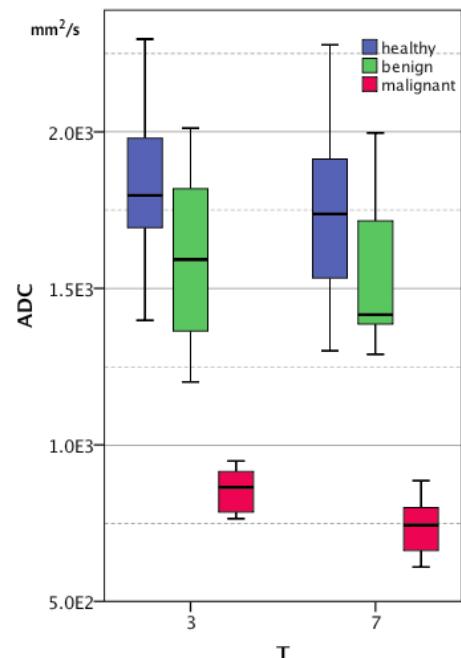


Figure 1: Boxplot of ADC values from normal tissue (blue, $n=3 \times 15$), benign (green, $n=7$) and malignant (red, $n=8$) lesion – at 3T and 7T.

Tissue	3T ($10^3\text{mm}^2/\text{s}$)	7T ($10^3\text{mm}^2/\text{s}$)	n	p
Healthy	1.85	1.75	3x15	0.033
Bening	1.60	1.58	7	0.352
Malignant	0.86	0.74	8	0.028

Figure 2: Table of average ADC values in different kind of tissues compared on 3T and 7T.

RESULTS: 15 lesions were identified – 7 benign and 8 malignant. Benign lesions were all fibroadenomas. In malignant cases, there were 7 invasive ductal carcinomas and one invasive lobular carcinoma. There was no significant difference between SNR in different regions of breast (3T: $p=0.306$, 7T: $p=0.086$) and neither between the 3T and 7T ($p = 0.841$). The SNR comparison can be seen as boxplots in Figure 3. ADC values in normal tissue were not significantly different between the various regions within the breast (3T: $p=0.924$; 7T: $p=0.622$). The boxplot comparison of ADC values at 3T and 7T in different lesion types and normal tissue can be seen in Figure 1. The average ADC values can be found in the table in Figure 2. They were found to be different for different field strengths, in two cases: in healthy tissue and in malignant lesion ROIs (paired values).

CONCLUSION: The ADC values, measured in this study at 3T, are in agreement with values reported previously [1]. The difference between ADC values at different field strength scanners was reported previously in liver and brain [2; 3]. Our results suggest that 7T DWI of breast can be performed with significantly higher spatial resolution than at 3T, with comparable SNR. Therefore, 7T DWI in breast cancer has the potential to improve lesion detection and/or differentiation. In addition, the high resolution of 7T DWI at $b=0\text{s/mm}^2$ (Figure 4) has very similar contrast as STIR and could, therefore, potentially replace additional T2-weighted MRI and save measurement time.

References: [1] Bogner et al. Radiology. 2009; 253(2):341-351, [2] Dale et al. Invest Radiol. 2010; 45(2):104-108, [3] Huisman et al. Eur Radiol. 2006; 16(8):1651-1658